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The role of oblique whistler waves in the development of bursts of localized parallel electric fields in the Earth's outer radiation belt

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Huge numbers of different types of nonlinear structures (double layers, electron holes, non-linear whistlers, etc. referred to as Time Domain Structures - TDS) have been observed by the electric field experiment on the Van Allen Probes. They often emerge on the forward edges of the wave structures and form temporal chains. Many of the observed non-linear structures are associated with whistler waves and some of them can be directly driven by whistlers. The parameters favorable for the generation of TDS were studied experimentally as well as through use of 2-D particle-in-cell (PIC) simulations. It is shown that an outward propagating front of whistlers and hot electrons amplifies oblique whistlers which collapse into regions of intense parallel electric field with properties consistent with recent observations of TDS from the Van Allen Probe satellites. Oblique whistlers seed the parallel electric fields that are driven by the beams. The resulting parallel electric fields trap and heat the precipitating electrons. These electrons drive spikes of intense parallel electric field with characteristics similar to the TDSs seen in the VAP data. The precipitating hot electrons propagate away from the source region in intense bunches rather than as a smooth flux.